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What is claimed is:

1. A polythioether comprising a structure having the formula I

$$— R^1 –[– S —(CH_2)_2 — O –[– R^2 — O –]_m– (CH_2)_2 — S — R^1 –]_n– \qquad I$$

wherein

R^1 denotes a divalent C_{2-6} n-alkyl, C_{3-6} branched alkyl, C_{6-8} cycloalkyl or C_{6-10} alkylcycloalkyl group, or $–[(–CH_2–)_p– X–]_q –(–CH_2–)_r–$,

R^2 denotes methylene, a divalent C_{2-6} n-alkyl, C_{2-6} branched alkyl, C_{6-8} cycloalkyl or C_{6-10} alkylcycloalkyl group, or $–[(–CH_2–)_p– X–]_q –(–CH_2–)_r–$,

X is one selected from the group consisting of O, S and $–NR^6 –$,

R^6 denotes H or methyl,

m is a rational number from 0 to 10,

n is an integer from 1 to 60,

p is an integer from 2 to 6,

q is an integer from 1 to 5, and

r is an integer from 2 to 10,

said polythioether being a liquid at room temperature and pressure.

2. The polythioether of claim 1 which has a glass transition temperature T_g not higher than -50°C.

3. The polythioether of claim 1 which, when cured, has a % volume swell not greater than 25% after immersion for one week in JRF type 1 at 60°C and ambient pressure.

4. The polythioether of claim 1 which has a number average molecular weight between about 500 and 20,000.

5. The polythioether of claim 1 having the formula II

$$A -(- [R^3]_y — R^4)_2 \qquad II$$

wherein

A denotes a structure having the formula I,

y is 0 or 1,

R^3 denotes a single bond when y = 0 and $- S - (CH_2)_2 - [- O — R^2 -]_m - O -$ when y = 1,

R^4 denotes –SH or $- S -(-CH_2-)_2- O — R^5$ when y = 0 and $- CH_2 = CH_2$ or $- (CH_2-)_2- S — R^5$ when y = 1,

R^5 denotes C_{1-6} n-alkyl which is unsubstituted or substituted with at least one –OH or $–NHR^7$ group, and

R^7 denotes H or a C_{1-6} n-alkyl group.

6. The polythioether of claim 5 wherein y = 0.

7. The polythioether of claim 6 wherein R^4 is –SH.

8. The polythioether of claim 7 wherein (i) when m = 1 and R^2 = n-butyl, R^1 is not ethyl or n-propyl, and (ii) when m = 1, p = 2, q = 2, r = 2 and R^2 = ethyl, X is not O.

9. The polythioether of claim 6 wherein R^4 is $- S -(-CH_2-)_2- O — R^5$.

10. The polythioether of claim 9 wherein R^5 is n-C_2H_5, n-C_4H_9 – OH or n-C_3H_7 – NH_2.

11. The polythioether of claim 5 wherein y = 1.

12. The polythioether of claim 11 wherein R^4 is – CH = CH_2.

13. The polythioether of claim 11 wherein R^4 is – $(CH_2–)_2$– S — R^5.

14. The polythioether of claim 13 wherein R^5 is n-C_3H_7 – OH.

15. The polythioether of claim 1 having the formula III

$$B–(A–[R^3]_y — R^4)_z \qquad \text{III}$$

wherein

A denotes a structure having the formula I,

y is 0 or 1,

R^3 denotes a single bond when y = 0 and – S – $(CH_2)_2$ – [– O — R^2 –]$_m$– O – when y = 1,

R^4 denotes –SH or – S –(–CH_2–)$_2$– O — R^5 when y = 0 and – CH_2 = CH_2 or – $(CH_2–)_2$– S — R^5 when y = 1,

R^5 denotes C_{1-6} n-alkyl which is unsubstituted or substituted with at least one –OH or –NHR^7 group,

R^7 denotes H or a C_{1-6} n-alkyl group,

z is an integer from 3 to 6, and

B denotes a z-valent residue of a polyfunctionalizing agent.

16. The polythioether of claim 15 wherein z = 3.

17. The polythioether of claim 16 which has an average functionality from about 2.05 to 3.00.

18. The polythioether of claim 15 wherein y = 0.

19. The polythioether of claim 18 wherein R^4 is –SH.

20. The polythioether of claim 18 wherein R^4 is – S –$(-CH_2-)_2$– O — R^5.

21. The polythioether of claim 15 wherein y = 1.

22. The polythioether of claim 21 wherein R^4 is – CH = CH_2.

23. The polythioether of claim 21 wherein R^4 is – $(CH_2-)_2$– S — R^5.

24. A method of producing the polythioether of claim 7 which comprises the step of reacting (n + 1) equivalents of a compound having the formula IV

$$HS — R^1 — SH \qquad IV$$

or a mixture of at least two different compounds having the formula IV, with (n) equivalents of a compound having the formula V

$$CH_2 = CH — O -[- R^2 — O -]_m - CH = CH_2 \qquad V$$

or a mixture of at least two different compounds having the formula V, in the presence of a catalyst selected from the group consisting of free-radical catalysts, ionic catalysts and ultraviolet light.

25. The method of claim 24 wherein said catalyst is a free-radical catalyst.

26. The method of claim 24 wherein (i) when m = 1 and R^2 = n-butyl, R^1 is not ethyl or n-propyl, and (ii) when m = 1, p = 2, q = 2, r = 2 and R^2 = ethyl, X is not O.

27. A method of producing the polythioether of claim 9 which comprises the step of reacting (n + 1) equivalents of a compound having the formula IV

$$HS — R^1 — SH \qquad IV$$

or a mixture of at least two different compounds having the formula IV, (n) equivalents of a compound having the formula V

$$CH_2 = CH — O -[- R^2 — O -]_m - CH = CH_2 \qquad V$$

or a mixture of at least two different compounds having the formula V, and about 0.05 to about 2 equivalents of a compound having the formula VI

$$CH_2 = CH — O — R^5 \qquad VI$$

or a mixture of two different compounds having the formula VI, in the presence of a catalyst selected from the group consisting of free-radical catalysts, ionic catalysts and ultraviolet light.

28. A method of producing the polythioether of claim 12 which comprises the step of reacting (n) equivalents of a compound having the formula IV

$$HS — R^1 — SH \qquad IV$$

or a mixture of at least two different compounds having the formula IV, with (n + 1) equivalents of a compound having the formula V

$$CH_2 = CH — O -[- R^2 — O -]_m - CH = CH_2 \qquad V$$

or a mixture of at least two different compounds having the formula V, in the presence of a catalyst selected from the group consisting of free-radical catalysts, ionic catalysts and ultraviolet light.

29. A method of producing the polythioether of claim 13 which comprises the step of reacting (n) equivalents of a compound having the formula IV

$$HS — R^1 — SH \qquad IV$$

or a mixture of at least two different compounds having the formula IV, (n + 1) equivalents of a compound having the formula V

$$CH_2 = CH — O -[- R^2 — O -]_m - CH = CH_2 \qquad V$$

or a mixture of at least two different compounds having the formula V, and about 0.05 to about 2 equivalents of a compound having the formula VII

$$HS — R^5 \qquad VII$$

or a mixture of two different compounds having the formula VII, in the presence of a catalyst selected from the group consisting of free-radical catalysts, ionic catalysts and ultraviolet light.

30. A method of producing the polythioether of claim 19 which comprises the steps of

(i) combining

(a) (n + 1) equivalents a compound having the formula IV

$$HS - R^1 - SH \qquad IV$$

or a mixture of at least two different compounds having the formula IV,

(b) (n) equivalents of a compound having the formula V

$$CH_2 = CH - O -[- R^2 - O -]_m - CH = CH_2 \qquad V$$

or a mixture of at least two different compounds having the formula V, and

(c) a z-valent polyfunctionalizing agent, wherein z is an integer from 3 to 6, to form a reaction mixture, and

(ii) reacting said reaction mixture in the presence of a catalyst selected from the group consisting of free-radical catalysts, ionic catalysts and ultraviolet light.

31. The method of claim 30 wherein said catalyst is a free-radical catalyst.

32. The method of claim 30 wherein said z-valent polyfunctionalizing agent is a trifunctionalizing agent.

33. The method of claim 32 wherein said trifunctionalizing agent is selected from the group consisting of triallylcyanurate, trimethylolpropane trivinyl ether, and 1,2,3-propanetrithiol.

34. A method of producing the polythioether of claim 20 which comprises the steps of

(i) combining

(a) (n + 1) equivalents of a compound having the formula IV

$$HS — R^1 — SH \qquad IV$$

or a mixture of at least two different compounds having the formula IV,

(b) (n) equivalents of a compound having the formula V

$$CH_2 = CH — O -[- R^2 — O -]_m - CH = CH_2 \qquad V$$

or a mixture of at least two different compounds having the formula V,

(c) about 0.05 to about (z) equivalents of a compound having the formula VII

$$CH_2 = CH — O — R^5 \qquad VII$$

or a mixture of two different compounds having the formula VII, and

(d) a z-valent polyfunctionalizing agent, wherein z is an integer from 3 to 6, to form a reaction mixture, and

(ii) reacting said reaction mixture in the presence of a catalyst selected from the group consisting of free-radical catalysts, ionic catalysts and ultraviolet light.

35. A method of producing the polythioether of claim 22 which comprises the steps of

(i) combining

(a) (n) equivalents a compound having the formula IV

$$HS - R^1 - SH \qquad IV$$

or a mixture of at least two different compounds having the formula IV,

(b) (n + 1) equivalents of a compound having the formula V

$$CH_2 = CH - O -[- R^2 - O -]_m - CH = CH_2 \qquad V$$

or a mixture of at least two different compounds having the formula V, and

(c) a z-valent polyfunctionalizing agent, wherein z is an integer from 3 to 6, to form a reaction mixture, and

(ii) reacting said reaction mixture in the presence of a catalyst selected from the group consisting of free-radical catalysts, ionic catalysts and ultraviolet light.

36. A method of producing the polythioether of claim 23 which comprises the steps of

(i) combining

(a) (n) equivalents of a compound having the formula IV

$$HS — R^1 — SH \qquad IV$$

or a mixture of at least two different compounds having the formula IV,

(b) (n + 1) equivalents of a compound having the formula V

$$CH_2 = CH — O -[- R^2 — O -]_m - CH = CH_2 \qquad V$$

or a mixture of at least two different compounds having the formula V,

(c) about 0.05 to about (z) equivalents of a compound having the formula VIII

$$HS — R^5 \qquad VIII$$

or a mixture of two different compounds having the formula VIII, and

(d) a z–valent polyfunctionalizing agent, wherein z is an integer from 3 to 6, to form a reaction mixture, and

(ii) reacting said reaction mixture in the presence of a catalyst selected from the group consisting of free-radical catalysts, ionic catalysts and ultraviolet light.

37. A polymerizable composition comprising

(i) about 30 to about 90 wt% of at least one polythioether of claim 1, said at least one polythioether having a glass transition temperature not higher than -55°C,

(ii) a curing agent in an amount from about 90 to about 150% of stoichiometric based on the amount of said at least one polythioether, and

(iii) about 5 to about 60 wt% of a filler,

with all wt% being based on the total weight of non-volatile components of the composition,

wherein said composition is curable at a minimum temperature of 0°C.

38. The polymerizable composition of claim 37 which has a glass transition temperature T_g not higher than -60°C.

39. The polymerizable composition of claim 37 which, when cured, has a percent volume swell not greater than 25 % after immersion in JRF type 1 for one week at 60°C and ambient pressure.

40. The polymerizable composition of claim 37 further comprising an additive selected from the group consisting of a pigment in an amount from about 0.1 to about 10 wt%, a thixotrope in an amount from about 0.1 to about 5 wt%, an accelerator in an amount from about 0.1 to about 5 wt%, a retardant in an amount from about 0.1 to about 5 wt%, an adhesion promoter in an amount from about 0.1 to about 5 wt%, and a masking agent in an amount from about 0.1 to about 1 wt%.

41. The polymerizable composition of claim 37 which comprises a mixture of at least two different polythioethers (i).

42. A polymerizable composition comprising

(i) about 30 to about 90 wt% of at least one polythioether of claim 1, said at least one polythioether having a glass transition temperature not greater than -50°C,

(ii) a curing agent in an amount from about 90 to about 150% of stoichiometric based on the amount of said at least one polythioether,

(iii) a plasticizer in an amount from about 1 to about 40 wt%, and

(iv) about 5 to about 60 wt% of a filler,

with all wt% being based on the total weight of non-volatile components of the composition,

wherein said composition is curable at a minimum temperature of 0°C.

43. The polymerizable composition of claim 42 which has a glass transition temperature T_g not greater than -55°C.

44. The polymerizable composition of claim 42 which, when cured, has a percent volume swell not greater than 25% after immersion for one week at room temperature and pressure.

45. The polymerizable composition of claim 42 wherein said plasticizer is selected from the group consisting of phthalate esters, chlorinated paraffins and hydrogenated terphenyls.

46. The polymerizable composition of claim 42 further comprising an additive selected from the group consisting of a pigment in an amount from about 0.1 to about 10 wt%, a thixotrope in an amount from about 0.1 to about 5 wt%, an accelerator in an amount from about 0.1 to about 5 wt%, a retardant in an amount from about 0.1 to about 5 wt%, an adhesion promoter in an amount from about 0.1 to about 5 wt%, and a masking agent in an amount from about 0.1 to about 1 wt%.

47. The polymerizable composition of claim 42 which comprises a mixture of at least two different polythioethers (i).